

Please read and send
in as full a discussion as
possible at earliest date.

Canadian Society of Civil Engineers.

INCORPORATED 1887.

ADVANCE PROOF—(*Subject to revision*).

N.B.—This Society, as a body, does not hold itself responsible for the statements and opinions advanced in any of its publications.

COMPETITION OF STEAM *vs.* ELECTRIC PARALLELS.

By C. H. DAVIS, M. CAN. SOC. C. E.

To be read Thursday March 13th. 1902.

In a recent discussion before the American Society of Civil Engineers the writer expressed the following conclusions as to the "Economic Electrical Future of Railroads" (see Vol. XLII., page 387 *et seq.* Transactions Am. Soc. C.E., December, 1899).

CONCLUSIONS.

"(1) Steam railroads will, in the near future, handle their suburban and short distance interurban passenger traffic and mail, express, baggage and light local freight carried in said suburban and interurban passenger trains, by electric motive power; and this, irrespective of whether operating expenses are affected favourably or unfavourably.

"(2) Steam railroads will not, in the near future, handle their freight traffic (other than mail, express, baggage and light local freight carried in suburban and interurban passenger trains), and long distance passenger traffic by any other motive power than steam locomotives.

"(3) Steam railroads may, under exceptional conditions of large volume and great density of passenger traffic over distances longer than under (1) and shorter than under (2), handle it by electric motive power, but such cases will be infrequent.

"(4) New railway lines, connecting very large centers of population, where frequent service at much higher speeds than can be attained now by steam locomotives on existing lines are conditions of success, will be operated by electric motors.

"There are three conditions under which suburban and short-distance interurban traffic will be handled profitably by steam railroads converting to electric traction:

"1. (a) Where units can be light and frequent, and operated over comparatively short distances.

"(b) Where gross receipts can be so increased by the change of system and mode of operation as to pay for the increased investment and possible increase in operating expenses.

"(c) Where competition of parallel electric roads compels the change, to save what traffic there is, irrespective of how operating expenses are affected.

"In the future development of steam railroad systems they will eventually be operated jointly with surface electric railways, either through actual mutual ownership or by traffic contracts, leases, etc.

"The above conclusions are obviously dependent upon what Mr. Prout properly defines as 'traffic conditions,' and not primarily engineering details or operating expenses."

In the discussion referred to it was shown that the first cost of an electrically equipped railroad, under steam railroad conditions, would be greater than present locomotive lines, assuming both to be new; and in case of a change from steam to electricity there would be an additional investment equivalent to a greater first cost. It was also shown that the cost of operating was unlikely to be less, with electricity, under existing steam railroad conditions, unless the number and frequency of the units approached that existing on our street railways. The inducement for a change of motive power must, therefore, come from possible increased revenue. Clean, light, airy cars, good road-bed neatly kept, fine stations and terminals, quick and frequent service, low total cost, etc., etc., influence passenger traffic on any line; it is obvious, however, that one or the other motive power cannot affect this traffic *per se* except on the one score of cleanliness in favour of the electric motor (very dense traffic not considered with practicability of closer headway by use of motor trains).

The use of electric motive power enables giving to the public quick, frequent service at a lower operating cost and total cost for transportation than can be offered by the use of steam locomotives, and it is this quicker and more frequent service that will cause the enormous increase in passenger traffic, justifying the change whenever it properly takes place. This is apparent when we realize that existing trolley parallels have not so much taken traffic from the steam railroad as they have created a traffic which did not formerly exist; in fact, most such electric parallels could not continue to exist if they were dependent upon this "captured!" traffic, although in some exceptional cases it has been considerable, and has seriously affected the steam railroad.

It is the object of this paper to show the existence of this "created" or "induced" traffic of electric roads due to their location and operative methods, which if properly applied to some existing steam railroads would produce the same if not greater results; and, furthermore, that it is this traffic, and not that taken away from the

parallel steam road which makes the "trolley parallel" a successful and useful enterprise; as much so to the steam road as to the community did the former more often utilize them.

LAWS OF PASSENGER TRAFFIC.

The laws of passenger movement are not well defined, and many of them are illusive and hard to determine; the causes of loss or gain are often largely a matter of individual judgment, so that the following outline of them must not be taken as in any way exact.

People travel from one place to another from (1), necessity, and (2), pleasure or whim.

They are induced to travel more or less often according to:

1. *Total Cost from Point of Departure to Objective Point and Return to Place of Beginning.*—As the total cost is reduced, travel, due to both fundamental causes, is increased; presumably less rapidly than the total cost falls. Note that the important factor to the passenger is total cost, and not cost per mile travelled.

2. *Total Time Consumed in Making the Round Trip.*—As the total time consumed is reduced, travel, due to both fundamental causes, is increased, presumably less rapidly than the total time falls. Velocity of transportation is not primarily effective in inducing travel, for it makes no difference to the passenger whether he be carried 80 miles in 30 minutes or only 12 miles.

3. *Total Conveniences Afforded the Passenger.*—These may be divided into:

(a) Proximity of departure and arrival points to possible passengers. As a "leave-at-your-door" service is approached, passenger traffic increases, but according to no known ratio to distance. Wellington laid down an approximate rule of loss of natural revenue for steam railroads of 10 per cent. per mile of removal from center of population as a minimum, 25 per cent. per mile as an ordinary maximum and a much larger percentage of loss, or even total loss, under certain conditions. Electric street railways have profited more by this kind of service which they offer the public than from any other reason; in furnishing it they give frequent and quick service, both of which are of the greatest importance in their effect on passenger traffic. Much less than a mile, however, will make or ruin the passenger traffic of a street railway.

(b) Frequency of the service. As the number of trips increases, so will the passengers, but less rapidly than the headway is shortened. A frequent service means less "total time" consumed.

(c) Character of terminals, stations, road-bed, equipment, and, in fact, all physical characteristics. That transportation system which offers, at the same rate and time, better physical conditions, which give comfort or even luxury to the passenger, will not only

secure competitive traffic, but induce that which would not otherwise exist.

4. *Total Population.*—As the population served increases, the passenger trips per capita per annum increase, and somewhat faster than the inhabitants, unless modified by density and distribution.

5. *Density.*—As the density increases, it is probable that the rides per capita per annum also increase, but whether more or less rapidly is uncertain.

6. *Distribution.*—A long, narrow town will give more rides per capita per annum than a square town having the same population.

7. *Character of the Industries and Population.*—The effect of various industries and the kind of population must have a decided effect on the passenger traffic, but probably according to no fixed laws, and certainly according to no known laws.

No "tailed defence" is offered for these laws other than what support they may obtain from other publications by the writer.

From the above we see that items (4), (5), (6) and (7) are independent of motive power or operative methods and therefore need not enter into our discussion.

Item (1) favours the "trolley" over steam because the location and mode of operating the former enables the delivery of transportation to the consumer at a much lower total cost per trip than can be done on our steam railroads.

Item (2) may favour one or the other system according to location and distance travelled; for short hauls the "trolley" will be favoured because of "leave-at-your-door" and frequent service.

Item (3) (a) and (b) decidedly favour the "trolley" system, and these affect traffic more than any others except the total cost; (c) favours our steam railroads, but as compared to a "leave-at-your-door," frequent service, at low total cost, it has relatively but little effect on the traffic.

It is seen how most conditions favour the "trolley" road much more than the steam railroad, especially due to their peculiar location and operative methods.

EFFECT OF COMPETITION.

One often hears of the competition which electric parallels have brought to our steam railroad systems. This has been exaggerated greatly, for most of the traffic of electric railways did not exist until created by low "total cost" and frequent and quick service, although, in certain isolated cases, the building of electric parallels has temporarily drawn away traffic from steam railroads, only to be recovered as the total volume naturally increased. This fluctuation and recovery in traffic, on parallels which changed motive powers, has been shown clearly in the building of elevated

and street railways in New York City. The Third Avenue Elevated so decreased the traffic on the horse surface road as to cause alarm to the stockholders; the conversion of the horse railway to a cable road decreased the travel on the elevated, which was subsequently more than recovered.

Fig. 1 gives a good example of the decrease in traffic on the Manhattan Elevated Railway in New York City, operated by steam locomotives, due to the increase in speed and frequency of service on the Metropolitan Street Railway in its changes from horse traction to cable and electric. The loss on the elevated road from 1893 to 1897 was approximately 40,000,000 passengers—part of which was due to the financial depression throughout the United States, as indicated by the "dip" in all curves on Fig. 2; how much this amounts to it is impossible to determine and most difficult to estimate, but an approximation can be made from the retardation of increase shown in the curve on Fig. 2, giving passenger trips on all electric roads in Massachusetts. Projecting the curve by connecting 1893 with 1897, it would indicate a natural proportional increase in 1894 of 17,000,000 more passengers than actually took place, which represents approximately the retardation due to the financial depression, or about 7.7 per cent. of the total traffic. If we assume

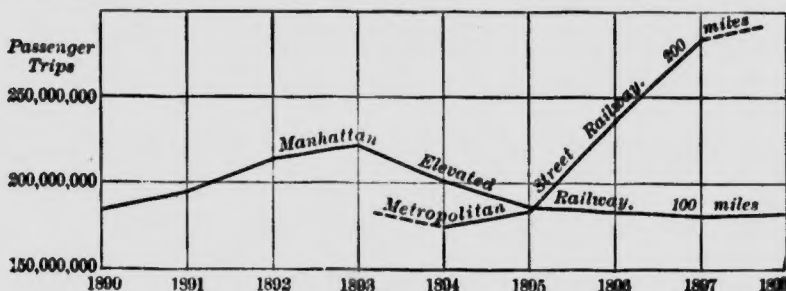


Fig. 1.

the same loss from the same cause on the elevated railways, about 17,000,000 of the above 40,000,000 loss is accounted for by the industrial depression, leaving 23,000,000 loss due to competition. During the same period the Metropolitan Street Railway gained about 110,000,000 passengers, or nearly five times as many as the elevated roads lost. The mileage of both roads remained constant, or nearly so, as in the Metropolitan curve are included, for the years taken, all roads now owned or operated by this company. These years also cover the change in motive power of this system. This increase in traffic on the street railways of New York undoubtedly comes largely from increase in speed, better physical conditions, such as track, cars, lighting, heating, cleanliness, open cars, etc., etc.

The elevated railways are operated under the same general conditions as exist on street railways, although the units are heavier,

but they are very frequent; of course, they have the disadvantage of being confined to what might be called "trunk" lines without feed-

TABLE No. 1.—EFFECT OF COMPETING ELECTRIC INTERURBAN PARALLELS TO STEAM RAILROADS.

Localities Connected.	Loss due to trolley parallels, as claimed by V. P. Hall of N. Y., N. H. & H. R. R., before Railroad State Committee, State Legislature of Connecticut (a).	Approximate distance in miles from Railroad Commission Map.	Trips per day as given by time table of N. Y., N. H. & H. R. R.	Trips per day of trolley roads.	Number of passengers carried by Electric Railway System in and between these towns, part of which traveled between them (1894).
Norwalk—Rowayton	50%	4.75	27	84	966 941
Bridgeport—Stratford	\$35 per day.	3.00	36	84	4 059 322 (Est.)
Bridgeport—Southport	80%	5.50	23	63	2 624 421
Waterbury—Naugatuck	90%	6.00	13	60	2 001 347
Wallingford—Meriden	80%	5.50	17	30	1 083 977
Birmingham—Ansonia	90%	3.00	16	112	1 090 263
Winnepauk—S. Norwalk	(b) 50%	3.00	12 966 571

(a) Total loss to N. Y., N. H. & H. R. R. from all parallel trolley roads in the State of Connecticut = \$4 000 per month = \$48 000 per annum, or $\frac{1}{4}$ of 1% loss on total passenger income of \$12 971 000 in 1894, as shown by Railroad Commission Reports.

(b) 64 passengers were carried on N. Y., N. H. & H. R. R. in the month of December, 1893, and 5 in the same month of 1894, or a total loss of 780 passengers per annum, at a possible maximum of 15 cents = \$117.

ers. These frequent units are now operated by steam locomotives, but a change to electric motors is about to take place. This change is not warranted by any decrease in operating expenses which will take place, either actual or sufficient, to offset the interest on the additional investment, although in the first years of electric operation figures will no doubt be produced which will appear to indicate such a result, as in two cases already cited. Nevertheless, the change, if made, will be a profitable one from the natural and induced increase in the traffic of the future, just as the large investments of our steam railroads in improved terminals, track, rolling stock and stations have been justified. Similar results will be the inducements for a change of operative methods on parts of our steam railroad systems, which change necessitates a change in motive power.

Table No. 1 has been prepared from a speech by Mr. Edwin B. Gager before the Railroad Committee of the State Legislature, at Hartford, Conn., March 22, 1895.* For many years bitter warfare has been waged against interurban electric railways by the Consolidated System (New York, New Haven and Hartford Railroad

* Those who are interested can obtain a reprint of Mr. Gager's Speech by addressing him at Derby, Conn.

Company), resulting in the electric parallel law, where "public convenience and necessity" must be demonstrated to the satisfaction of the Superior Court before an electric railway can be built between two points already connected by a steam railroad. More unwise legislation against a natural progress, which would also benefit those whose influence created it, can scarcely be imagined. It is fair to assume that in this controversy—for the street railways naturally opposed such legislation—both sides produced the strongest arguments in support of their respective contentions; the Consolidated presenting losses of traffic, while the street railways insisted that their passenger travel was mostly an induced one which did not and could not exist under steam railroad conditions and operative methods.

An examination of Table No. 1 shows conclusively how the steam railroads convicted themselves. The Consolidated System only claimed a total loss of \$4,000 per month, or \$48,000 per annum on the entire system, being about $\frac{1}{4}$ of 1 per cent. of their gross passenger revenue. If the average fare were 10 cents, this would mean a total loss of 480,000 passengers per annum out of a total of 44,448,324, or 1.1 per cent.; but 1894 was the year of financial depression, when the steam railroads of Massachusetts lost 8.3 per cent. of their former passenger traffic, so that only part of this loss on the Consolidated was due to trolley parallels. While the total loss to the Consolidated was given by its officers, all the towns between which it occurred were not stated, so that in Table No. 1 the 12,365,571 passenger trips, between and in a few of these towns, is only part of the total passenger traffic of the street railways serving all localities where such loss took place. Whether this figure should be increased by 50 to 100 per cent. or more, we cannot say, but, in any case, the data are sufficient to show the large induced traffic of street railways; or, in other words, systems which give low fares, frequent service, short total time consumed in round-trip, and a "leave-at-your-door" service.

To emphasize the fact of what might be called a "door-to-door traffic," which can become an "induced traffic" under proper operative conditions, and to bring out this fact more clearly, Fig. 2 and Table No. 2 have been prepared, and these again show what a small part of the traffic of street railways has come from the losses of steam railroads, and, also, that a large part of this loss has been wrongly attributed to electric parallel competition.

The passenger traffic on steam railroads in Massachusetts has increased constantly from year to year since 1870, except during two periods, both of which coincide with industrial depression. This is shown by Curve 1, Fig. 3, where the loss began in 1873 and 1893. Short-haul passenger traffic is but little affected by financial conditions when compared with the effect on long-haul traffic; this

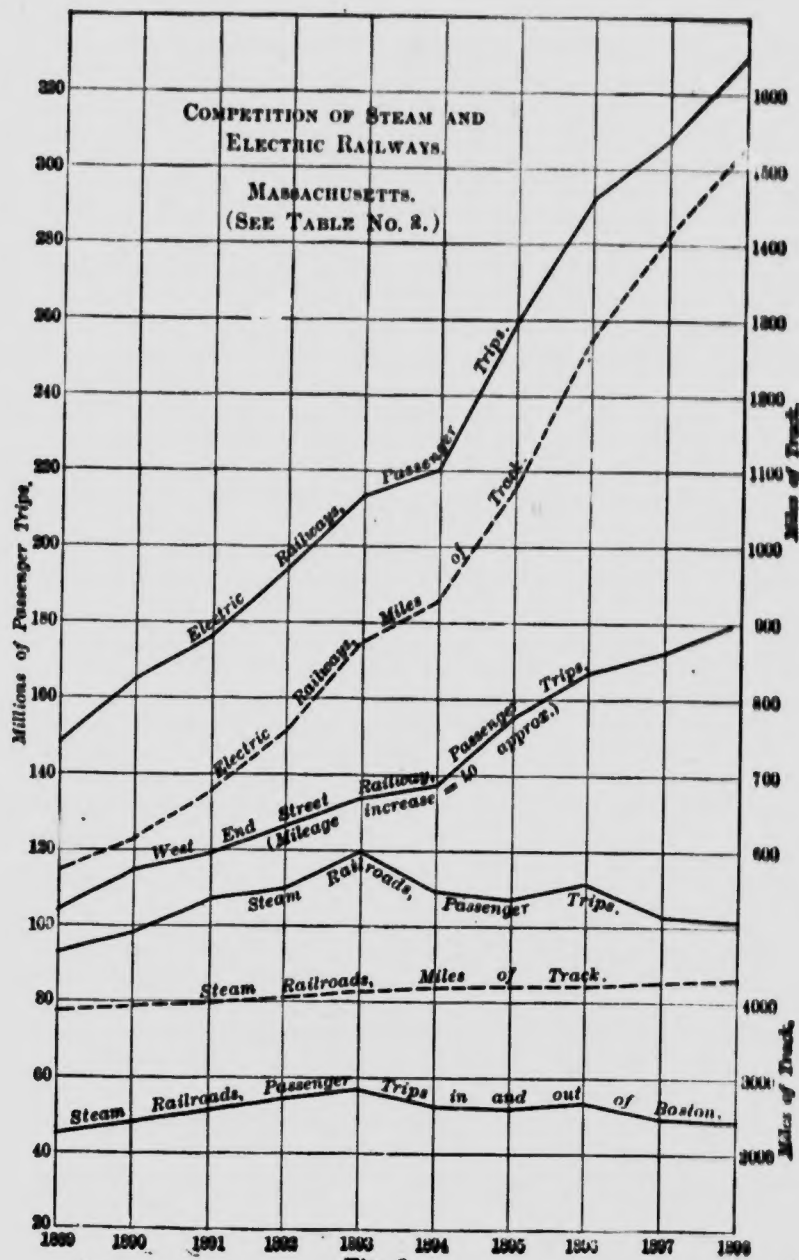


Fig. 2.

is due mainly to necessity being the basis of short-haul passenger business, or, in other words, it is composed mostly of commuters or suburban and interurban travel. Curve 2, Fig. 3, corroborates this position, for we see that the passenger trips on street railways

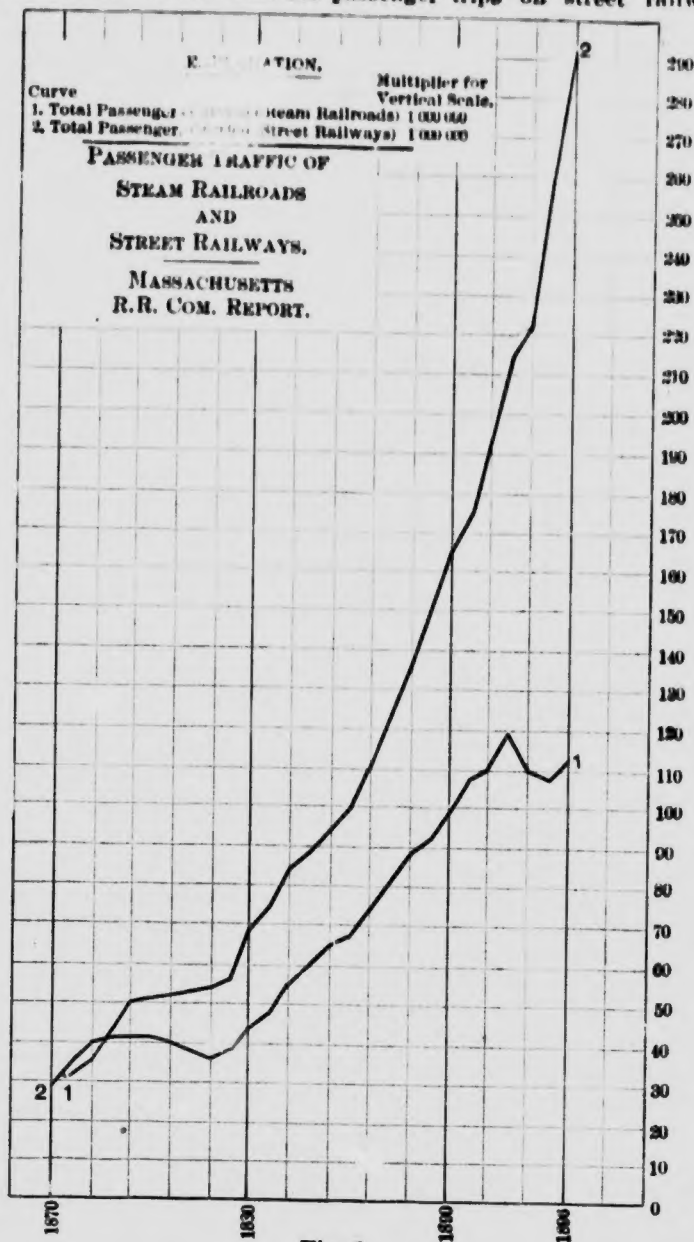


Fig. 3.

(short-hauls, from necessity, as the controlling factors in volume of traffic on these systems), increased after 1874 and 1893, although less rapidly than in the year previous, but there was no actual decrease. This curve brings out another interesting fact, namely, the quicker recovery of electric roads and their more rapid increase in passenger traffic than when operated by horse-power, again supporting our position. In Massachusetts electric railway mileage has increased along with the passenger traffic (1889 to 1898) 163 per cent. in the former to 123 per cent. in the latter, or, approximately, each has kept pace with the other. In other words, these railways have been built where traffic did not previously exist, nor could it be produced by the steam railroads under existing conditions; it has been "induced" by the character of the electric roads and their operative methods. Steam railroad mileage has only increased 10 per cent. in Massachusetts during the same period, and passenger traffic 9.6 per cent. (net).

TABLE No. 2.—COMPARATIVE LOSS ON STEAM RAILROADS AND GAIN ON ELECTRIC RAILWAYS—MASSACHUSETTS.—(See Fig. 2.)

Year.	Loss in passenger trips per annum on all steam railroads in Massachusetts.	Loss in passenger trips per annum on steam railroads in and out of Boston.	Loss in passenger trips per annum on steam railroads in Massachusetts omitting those in and out of Boston. Column 3 minus Column 2.	Gain in passenger trips per annum on all street railways in Massachusetts.	Amounts in Column 5 divided by those in Column 2.	Gain in passenger trips per annum on West End Street Railway system in and out of Boston.	Amounts in Column 7 divided by those in Column 3.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1889 to 1893....	{ 96 250 648 }	{ 11 406 434 }	{ 14 844 214 }	{ 65 362 006 }	2.4	20 680 468	2.6
1894.....	{ Increase }	{ Increase }	{ Increase }	{ Increase }			
1895.....	10 345 763	3 894 940	6 520 823	6 912 080	0.65	3 164 681	0.6
1896 (Increase).....	1 577 836	740 680	837 156	39 330 209	24.9	18 208 057	24.5
1897.....	8 885 161	3 808 480	5 076 681	16 325 281	1.6	5 592 225	1.4
1898.....	808 168	723 748	79 420	22 205 405	27.6	8 766 782	12.1
1896 (Increase).....	21 611 923	9 097 848	12 514 080
	3 772 703	1 483 774	2 288 929	32 564 635	8.6	11 630 732	7.8
Net decrease } 1894 to 1898. }	17 839 225	7 614 074	10 225 151	117 327 620	6.5	47 457 677	6.2

Turning to Table No. 2 and Fig. 2, we see that the net loss of passenger traffic on all the steam railroads of Massachusetts, from 1893 to 1898, was 17,839,225, but during the same years the street railways increased 117,327,620, or 6.5 times the loss of the steam railroads. If 7.7 per cent. of the traffic was lost, due to financial conditions (as estimated heretofore), then only 8,600,000 passenger trips were lost to the steam roads of the State from trolley competition. If the average fare lost was 10 cents (when secured by the street railway the fare would be halved or even less for them),

the total amounted to \$860,000, or 2.4 per cent. on the gross passenger earnings and 1.1 per cent. on the gross earnings of the steam railroads; this would only amount to about 1 per cent. of the total net earnings. Again, the net loss to steam railroads in and out of Boston, from 1893 to 1898, was 7,614,074, while the West End Street Railway (controlling practically all street railways in and out of Boston), increased 47,457,677 or 6.2 times the loss of the steam roads. Applying the same argument, only 3,225,000 passengers were lost by the steam roads in and out of Boston, due to this competition. This would not be fair, however, for this traffic is made up more largely of commuters than long-haul passengers. Assume it at 5,000,000, which is undoubtedly too high, and with an average commutation rate of 7 cents, the loss is only \$350,000 at the maximum. Furthermore, the greatest gains of the street railways throughout the State, and the West End Street Railway alone were in 1895 and 1898, when the steam roads lost the least. All these data point to the conclusion, already stated, that competition does not take place to the extent usually believed; while an "induced" traffic is created by the low fares, frequent, quick and "leave-at-your-door" service, rendered possible by the physical characteristics and operative methods of the electric roads.

As an example of how a steam railroad could adopt the methods of the "trolleys," together with some natural advantages the former now have over the latter, we call attention to Ansonia, Derby and Birmingham, a center of 25,000 to 30,000 people situated about 10 to 12 miles from New Haven, Connecticut, with a population of 80,000 to 100,000. The New York, New Haven & Hartford Railroad connects the two centres which have their own local electric street railways; when the steam railroad owns the systems of street railways in both towns, their cars will pick up passengers at either centre, will pass on to the present steam tracks on the right-of-way of the New Haven and Derby Railroad (New York, New Haven & Hartford Railroad Company), run at high speed without stops to the other centre, pass on to the local street railway tracks there and distribute its passengers where they desire, all for one fare. Such a system operated by electric motors would be a financial success, where a line like the third-rail between Hartford and New Britain is a failure in the true sense. Many other similar examples might be given, but this indicates the future electrical development of our steam railroads to enable their benefiting from the enormous increase in traffic that is possible to "induce" by adopting the operative methods of our present "trolley" roads and approaching them in location, with the added advantage of their own right-of-way between centres of population where higher speeds can be maintained than is now possible on street railways.

It might be said, with apparent justice, that there are cases where a steam road has been seriously injured by an electric parallel and that these cases disprove our contention. There are, how-

ever, exceptions to every rule which "prove them." An examination of such cases will almost always lead to the conclusion that the steam railroad was disadvantageously, poorly, or even badly, located for local traffic, and naturally would not prove profitable until such time had elapsed as enabled developing and populating the region immediately contiguous to the line. Under such circumstances a "trolley parallel" which was located more nearly along the natural artery of travel would seriously cripple the steam road although it might be just emerging from barren years to those of greater fruit.

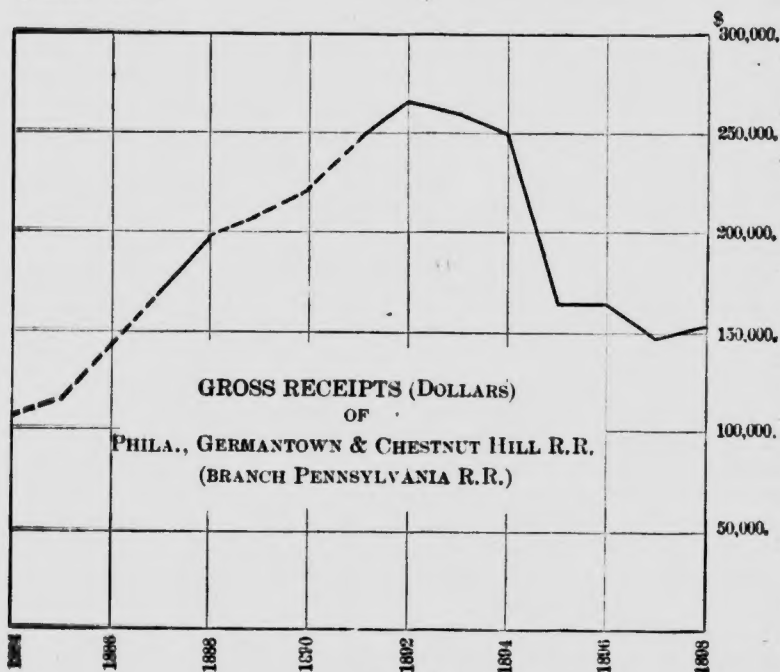


Fig. 4.

An example of the effect of a "trolley parallel" upon such a road is shown in Table No. 3 and Fig. 4; they speak for themselves. While the gross receipts given in Table No. 3 and Fig. 4 include all receipts (passenger freight, express, mails, etc.), the effect of trolley competition is nevertheless distinctly and relatively shown, for the trolleys carried nothing but passengers, so that the loss of freight, express, mails, etc., must have been very slight losses to the steam road. The horse railways from Philadelphia to Germantown, Pennsylvania, were electrified during 1895-96. It is believed the future will undoubtedly bear out the position taken in this paper.

(Note:—This article was prepared early in 1899; data for that year and 1900 now just at hand confirm the various judgments above expressed).

TABLE No. 3.—STATISTICS OF THE PHILADELPHIA, GERMANTOWN & CHESTNUT HILL R.R. (Branch of Pennsylvania R.R.)

Year.	Length of Road.	Miles	Gross Receipts.	Operating Expenses.	Net Receipts applicable to Taxes, Rentals, Interest, Dividends.	Taxes and other Expenses.	Interest.		Total Charges against Net Receipts from Operation. (Cols. 6+7+8.)	Net Receipts (Surplus or Deficit) applicable to Dividends or Losses to Capital Stock (difference between cols. 5 and 9.)	Cost of Road and Equipment	Par Value.		Floating Debt.	Total Par Value Securities Issued and Floating Debt. (Cols. 13+14+15.)	PER CENT.					
							On Bonds.	On Floating Debt.				Of Capital Stock Issued.	Of Mortgage Bonds Issued.			(17)	(18)	(19)	(20)	(21)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	
84	6.75	—	—	—	—	45,000	—	—	—	—	2,000,000	1,000,000	—	—	2,000,000	—	—	—	—	—	
1885	"	—	—	—	—	"	—	—	—	"	"	"	"	—	"	—	—	—	—	—	
86	"	—	—	—	—	"	—	—	—	"	"	"	"	—	"	—	—	—	—	—	
87	"	170,421	130,425	30,966	8,000	"	—	—	(c)	32,569	"	"	"	249,300	2,249,300	76	1.59	3.20	1.30	—	
88	"	198,564	146,745	52,819	7,987	"	12,465	65,452	12,633	19,408	"	"	"	91,300	2,091,300	73	1.99	1.23	3.27	—	
89	"	—	—	—	8,332	"	4,590	57,922	—	2,465	"	"	"	49,300	2,049,300	—	—	—	—	—	
1890	"	—	—	—	7,947	"	2,465	56,412	—	2,018	"	"	"	40,300	2,047,380	65	3.90	4.50	—	3.25	
91	"	248,754	162,417	86,337	6,750	"	20,700	72,568	—	19,408	2,036,060	"	"	414,000	2,414,000	65	3.52	4.50	—	1.94	
92	7.06	264,737	172,636	92,091	6,898	"	25,000	80,636	—	19,164	2,500,895	"	"	500,000	2,500,000	61	3.58	4.50	—	1.91	
93	13.37	299,036	159,238	89,800	10,636	"	—	90,444	6,080	2,527,697	1,253,000	1,253,000	—	—	2,526,000	66	2.01	4.02	0.48	—	
94	"	249,507	165,303	84,304	35,000	56,835	"	72,088	50,532	2,528,751	"	"	"	25,308	2,551,308	87	0.24	0.47	4.03	—	
1895	"	164,267	143,031	21,226	15,253	"	1,265	62,291	43,316	—	"	"	"	86,754	2,612,754	84	0.59	1.07	3.43	—	
96	"	164,771	138,796	25,975	11,191	"	4,337	73,774	56,603	—	"	"	"	138,723	2,664,723	89	0.17	0.02	4.48	—	
97	"	149,698	132,497	16,171	11,602	"	6,936	74,835	60,245	—	"	"	"	—	—	90	0.13	(d)	4.50	—	
98	"	153,118	138,818	14,300	11,064	"	—	—	—	—	—	—	—	—	—	—	—	—	—	—	

(a) Assumed. (b) Estimated to be at 5 per cent. per annum. (c) Derived from the assumed amount (a). (d) Not only no earnings applicable to Charges on Bonds, but a Deficit of \$3,400 in any Ability to Meet Interest on Unfunded Debt.